

## **Case Study: Formal Inspections at the Jet Propulsion Laboratory**

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### Overview -

The Jet Propulsion Laboratory (JPL) of the California Institute of Technology is a federally funded research and development center operating under contract to the National Aeronautics and Space Administration (NASA). JPL's charter emphasizes the exploration of the solar system including observations of Earth as well as other stellar systems and extra-solar-system bodies.

Within JPL, the Software Product Assurance (SPA) Section helps to ensure the operational integrity of the software within the system. SPA evaluates the operational requirements, the acceptability and readiness of all software, hardware/software interfaces, and the integrity of the completed software before its final release into the operational environment. To achieve this objective SPA carries out two tasks. First, SPA assures that appropriate institutional requirements are adopted by the project, that software development organizations comply with the requirements, and that project-mandated software assurance activities are carried out. Second, advanced techniques are researched, transferred, and tailored to the JPL environment to improve the quality of the project's software. SPA also develops and conducts advanced research and training activities for engineering and quality of software intensive systems, and assembles an archive of software product and process metrics to monitor the status and history of JPL projects.

### Original Situation -

No lab-wide guidelines were in place for implementing technical status reviews. The application of formal reviews and walkthroughs at JPL was sporadic with a great deal of variability from project to project. Metrics were not consistently collected or maintained, and were not being fed back to the software development organizations for improvement in the software development process.

### Objectives, Plans, and Actuals -

The overall goals of the Formal Inspection Program developed by SPA are to lower the defect density of software products entering testing by at least a factor of three, and to improve the quality of software entering the operations phase to under one defect per thousand lines of code. Inspections are used to detect and correct defects in engineering products prior to test and are conducted early in the development lifecycle when defects are less expensive to fix.

The first step in achieving these goals, completed in December 1987, was to tailor the inspection process developed by Michael Fagen at IBM for use in the JPL environment. Inspections at JPL, termed Formal Inspections, are detailed technical reviews performed on intermediate engineering products early in the lifecycle. JPL Formal Inspections are a highly structured, well defined process for identifying and correcting defects (see attached diagram, Software Inspections Process at JPL). The inspections are carried out by a small group of peers from organizations having a vested interest in the engineering product. Each inspection is monitored through metrics and controlled through checklists.

The second step was the development of two courses to introduce Formal Inspections to JPL, a day and a half practitioners' course, and a two hour managers' course. The practitioners' course was designed to train JPL engineers in the use of Formal Inspections (see attached course description), and was first taught in February 1988. Since that time approximately 40 courses have been taught at JPL with over 400 people trained. Over 10 managers' courses have been presented with over 120 managers trained.

Finally, to optimize data analysis, a JPL Software Inspections Metrics Database was started in September 1988. Metrics on time, team composition, defects and product characteristics are kept on each inspection. Target values for inspection process input variables are set (team size, inspection rates, time expended, inspection work product size, etc.), and data is monitored and analyzed to ensure a quality process and product.

#### Results and Significance -

Over 350 inspections have been conducted on 11 projects at JPL since their introduction. Substantial gains in the quality of early lifecycle products have resulted from inspections and JPL is moving toward the stated goals.

Formal Inspections applied to requirements have uncovered an average of one major error in every three pages. The most common of these errors has been missing requirements, which account for 67% of the major errors found (see attachment "Distribution of Software Requirements Defects" ). Completeness of requirements documents is one of the most significant of many measurable improvements resulting from Formal Inspections.

Additional results showed that finding and fixing errors through inspections was significantly less costly than similar rework performed during the test phases. Inspections required an average time of 0.5 work hours to fix a defect, compared to a range of 5 to 18 work hours to fix a defect during formal testing.

Benefits from data monitoring include 1) controlling the inspection process across multiple projects, 2) deriving good target values for inspection variables (product size, team composition, time reviewed, etc.), 3) understanding in statistical terms the nature of the software engineering process, and 4) pointing the direction toward further improvement of quality of JPL software products.

Formal Inspections at JPL contain many features of Total Quality Management. Formal Inspections provide leadership in quality in having a process owner, the Chief Moderator, by supporting a training program, in developing a lab-wide policy of Requirements Inspections (now under consideration), and by maintaining a continual commitment to quality. Overall, software quality improves dramatically by integrating Formal Inspections with Total Quality techniques.

Due to the high risk inherent in space exploration, JPL requires extremely high quality and reliability in software. JPL continuously seeks new methods to achieve this level of quality. Over the last four years, Formal Inspections have proven effective in detecting and eliminating defects and instilling quality in the software products and software development process at JPL.

#### Publication -

A Formal Inspection Technology Transfer Program has been developed to support other NASA centers based on an established training and follow-up program that has been in place at JPL for four years. The training materials have been tailored to all NASA centers. In order for centers to be self sufficient, training and certification of local instructors is included in this program. Currently, one center has completed the training, a second center is in progress, and plans are being made for technology transfer to two other centers. This Formal Inspection Technology Transfer Program can also provide support for 1) awareness activities and materials, 2) data base support of inspection metrics, 3) local inspection program planning, 4) tailoring inspections for local needs, 5) consultation for center head moderator and trainers.

John Kelly, Chief Moderator for JPL, is a charter member of the steering committee for the Software Engineering Inspection and Review Organization.

A list of publications and presentations on Formal Inspections at JPL is attached.

## The Software Inspection Process at JPL

